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Class XI

Class XII

5 Work, Energy and Power

1. A block of mass $m = 0.1$ kg is connected to a spring of unknown spring constant k. It is compressed to a distance x from its equilibrium position and released from rest. After approaching half the distance $\left(\frac{x}{2}\right)$ from equilibrium position, it hits another block and comes to rest momentarily, while the other block moves with a velocity 3 ms^{-1}.
The total initial energy of the spring is

(a) 0.3 J (b) 0.6 J
(c) 0.8 J (d) 1.5 J

2. 300 J of work is done in sliding a 2 kg block up an inclined plane of height 10 m. Taking $g = 10\ m/s^2$, work done against friction is

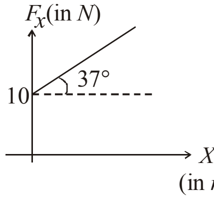
(a) 100 J (b) zero
(c) 1000 J (d) 200 J

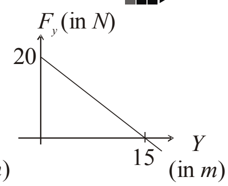
3. A particle experiences a variable force $\vec{F} = (4x\hat{i} + 3y^2\hat{j})$ in a horizontal x-y plane. Assume distance in meters and force is newton. If the particle moves from point (1, 2) to point (2, 3) in the x–y plane, the kinetic energy changes by

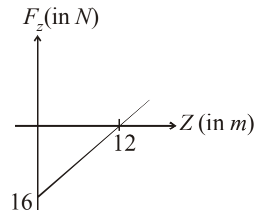
(a) 50.0 J (b) 12.5 J
(c) 25.0 J (d) 0 J

4. The components of a force acting on a particle are varying according to the graphs shown. When the particles move from (0, 5, 6) to (2, 10, 0) then the work done by this force is

Tricky







(a) 192 J (b) $\frac{400}{3}$ J
(c) $\frac{287}{2}$ J (d) None of these

5. A particle of mass m is moving in a circular path of constant radius r such that its centripetal acceleration (a) is varying with time t as $a = k^2rt^2$ where k is a constant. The power delivered to the particle by the force acting on it is given as

(a) zero (b) $mk^2r^2t^2$
(c) mk^2r^2t (d) mk^2rt

6. One man takes 1 min. to raise a box to a height of 1 metre and another man takes 1/2 min. to do so. The energy of the

(a) two is different (b) two is same
(c) first is more (d) second is more

7. If the momentum of a body is increased by 50%, then the percentage increase in its kinetic energy is

(a) 50% (b) 100%
(c) 125% (d) 200%

8. A ball dropped from a height of 2m reaches to a height of 1.5m before hitting the ground. Then the percentage of potential energy lost is

(a) 25 (b) 30
(c) 50 (d) 100

9. A body starts from rest and acquires a velocity V in time T. The work done on the body in time t will be proportional to

(a) $\frac{V}{T}t$ (b) $\frac{V^2}{T}t^2$ (c) $\frac{V^2}{T^2}t$ (d) $\frac{V^2}{T^2}t^2$

10. A 60 HP electric motor lifts an elevator having a maximum total load capacity of 2000 kg. If the frictional force on the elevator is 4000 N, the speed of the elevator at full load is close to: (1 HP = 746 W, g = 10 ms^{-2})

(a) 1.7 ms^{-1} (b) 1.9 ms^{-1}
(c) 1.5 ms^{-1} (d) 2.0 ms^{-1}

11. A running man has half the kinetic energy of that of a boy of half of his mass. The man speeds up by 1m/s so as to have same K.E. as that of the boy. The original speed of the man will be

(a) $\sqrt{2}$ m/s (b) $(\sqrt{2}-1)$ m/s
(c) $\frac{1}{(\sqrt{2}-1)}$ m/s (d) $\frac{1}{\sqrt{2}}$ m/s

12. A steel ball of mass 5g is thrown downward with velocity 10 m/s from height 19.5 m. It penetrates sand by 50 cm. The change in mechanical energy will be (g = 10 m/s^2)

(a) 1J (b) 1.25 J (c) 1.5 J (d) 1.75 J

13. A ball is allowed to fall from a height of 10 m. If there is 40% loss of energy due to air friction, then velocity of the ball when it hit the ground is

(a) $\sqrt{190}$ m/s (b) $\sqrt{180}$ m/s
(c) $\sqrt{150}$ m/s (d) $\sqrt{120}$ m/s

14. A body falls freely under gravity. Its velocity is v when it has lost potential energy equal to U. What is the mass of the body?

(a) U^2/v^2 (b) $2U^2/v^2$ (c) $2U/v^2$ (d) U/v^2

15. When a body is projected vertically up from the ground with certain velocity, its potential energy and kinetic energy at a point A are in the ratio 2 : 3. If the same body is projected with double the previous velocity, then at the same point A the ratio of its potential energy to kinetic energy is

(a) 9 : 1 (b) 2 : 9 (c) 1 : 9 (d) 9 : 2

16. A uniform chain of length 2 m and mass 0.1 kg overhangs a smooth table with its two third part lying on the table. Find the kinetic energy of the chain as it completely slips- off the table.

(a) $\frac{8}{9}$ J (b) $\frac{12}{5}$ J (c) $\frac{3}{7}$ J (d) $\frac{11}{3}$ J

17. A man places a chain of mass m and length L on a table slowly. Initially the lower end of the chain just touches the table. The man drops the chain when half of the chain is in vertical position. Then work done by the man in this process is

(a) $-mg\frac{L}{2}$ (b) $-\frac{mgL}{4}$
(c) $-\frac{3mgL}{8}$ (d) $-\frac{mgL}{8}$

18. A particle of mass 10 g moves along a circle of radius 6.4 cm with a constant tangential acceleration. What is the magnitude of this acceleration if the kinetic energy of the particle becomes equal to 8×10^{-4} J by the end of the second revolution after the beginning of the motion?

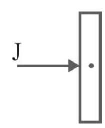
(a) 0.1 m/s^2 (b) 0.15 m/s^2
(c) 0.18 m/s^2 (d) 0.2 m/s^2

19. Particle A of mass m_1 moving with velocity $(\sqrt{3}\hat{i}+\hat{j})\ ms^{-1}$ collides with another particle B of mass m_2 which is at rest initially. Let $\vec{V}_1$ and $\vec{V}_2$ be the velocities of particles A and B after collision respectively. If $m_1 = 2m_2$ and after collision $\vec{V}_1 = (\hat{i}+\sqrt{3}\hat{j})\ ms^{-1}$, the angle between $\vec{V}_1$ and $\vec{V}_2$ is :

(a) 15º (b) 60º (c) – 45º (d) 105º

20. A straight bar, of mass 15 kg and length 2 m, at rest on a frictionless horizontal surface, receives an instantaneous impulse of 7.5 Ns perpendicular to the bar. If the impulse is applied at the mid point of the bar, the energy transfered is

(a) 3.2 J
(b) 1.9 J
(c) 3.8 J
(d) 2.5 J



21. A ball whose kinetic energy is E, is projected at an angle of 45° to the horizontal. The kinetic energy of the ball at the highest point of its flight will be

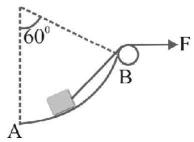
(a) E (b) $E/\sqrt{2}$ (c) E/2 (d) zero.

22. A porter lifts a heavy suitcase of mass 80 kg and at the destination lowers it down by a distance of 80 cm with a constant velocity. Calculate the work done by the porter in lowering the suitcase. (take g = 9.8 ms^{-2})

(a) –62720.0 J (b) –627.2 J
(c) +627.2 J (d) 784.0 J

23. A 10 kg block is pulled in the vertical plane along a frictionless surface in the form of an arc of a circle of radius 10 m. The applied force is of 200 N as shown in figure. If the block had started from rest at A, the velocity at B would be

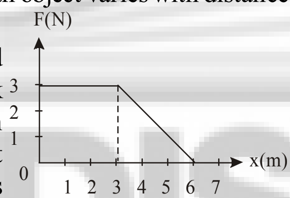
(a) 1.7 m/s
(b) 17 m/s
(c) 27 m/s
(d) 34 m/s



24. Calculate the work done on the tool by $\vec{F}$ $(11.25\,\hat{i} + 11.25\,\hat{j})$N if the tool is first moved out along the x-axis to the point x = 3.00m, y = 0 and then moved parallel to the y-axis to x = 3.00m, y = 3.00 m.

(a) 67.5 J (b) 85 J
(c) 102 J (d) 7.5 J

25. A force F acting on an object varies with distance x as shown here. The force is in N and x in m. The work done by the force in moving the object from x = 0 to x = 6 m is



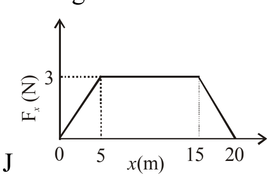
(a) 18.0 J (b) 13.5 J
(c) 9.0 J (d) 4.5 J

26. A particle describe a horizontal circle of radius 0.5 m with uniform speed. The centripetal force acting is 10 N. The work done in describing a semicircle is

(a) zero (b) 5 J (c) 5π J (d) 10π J

27. A force F_x acts on a particle such that its position x changes as shown in the figure. The work done by the particle as it moves from x = 0 to 20 m is

(a) 37.5 J (b) 10 J
(c) 45 J (d) 22.5 J



28. A cord is used to lower vertically a block of mass M, a distance d at a constant downward acceleration of g/4. The work done by the cord on the block is

(a) $Mg\frac{d}{4}$ (b) $3Mg\frac{d}{4}$

(c) $-3Mg\frac{d}{4}$ (d) Mg d

29. A spring of spring constant 5×10^3 N/m is stretched initially by 5 cm from the unstretched position. Then the work required to stretch it further by another 5 cm is

(a) 18.75 J (b) 25.00 J
(c) 6.25 J (d) 12.50 J

30. The position of a particle of mass 4 g, acted upon by a constant force is given by $x = 4t^2 + t$, where x is in metre and t in second. The work done during the first 2 seconds is

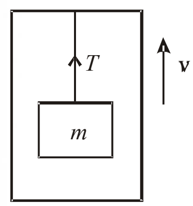
(a) 128 mJ (b) 512 mJ
(c) 576 mJ (d) 144 mJ

31. A body moves a distance of 10 m along a straight line under the action of a force of 5 newtons. If the work done is 25 joules, the angle which the force makes with the direction of motion of body is

(a) 0° (b) 30°
(c) 60° (d) 90°

32. A block of mass m is suspended by a light thread from a lift. The lift is moving upward with uniform velocity v. From the frame of lift, the work done by tension on the block in t seconds will be

(a) $-mgvt$
(b) 0
(c) $\frac{mgvt}{2}$
(d) $mgvt$



33. The work done by a force $\vec{F} = (-6x^3\hat{i})\,N$, in displacing a particle from $x = 4\,m$ to $x = -2\,m$ is

(a) 360 J (b) 240 J
(c) –240 J (d) –360 J

34. Work done by static friction on an object

(a) may be positive (b) must be negative
(c) must be zero (d) None of these

35. Calculate the K.E and P.E. of the ball half way up, when a ball of mass 0.1 kg is thrown vertically upwards with an initial speed of 20 ms^{-1}.

(a) 10 J, 20 J (b) 10 J, 10 J
(c) 15 J, 8 J (d) 8 J, 16 J

36. At time t = 0s particle starts moving along the x-axis. If its kinetic energy increases uniformly with time t, the net force acting on it must be proportional to

(a) $\sqrt{t}$ (b) constant

(c) t (d) $\frac{1}{\sqrt{t}}$

37. Two bodies of masses 4 kg and 5 kg are moving with equal momentum. Then the ratio of their respective kinetic energies is

(a) 4 : 5 (b) 2 : 1 (c) 1 : 3 (d) 5 : 4

38. A rod of mass m and length ℓ is made to stand at an angle of 60° with the vertical. Potential energy of the rod in this position is

(a) $mg\ell$ (b) $\frac{mg\ell}{2}$ (c) $\frac{mg\ell}{3}$ (d) $\frac{mg\ell}{4}$

39. A 2 kg block slides on a horizontal floor with a speed of 4m/s. It strikes a uncompressed spring, and compresses it till the block is motionless. The kinetic friction force is 15N and spring constant is 10,000 N/m. The spring compresses by

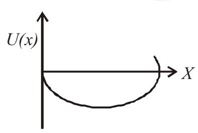
Critical Thinking

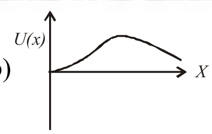
(a) 8.5 cm (b) 5.5 cm (c) 2.5 cm (d) 11.0 cm

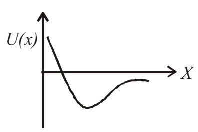
40. The potential energy of a conservative system is given by $U = ay^2 - by$, where y represents the position of the particle and a as well as b are constants. What is the force acting on the system ?

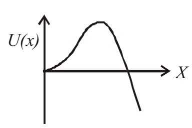
(a) – ay (b) – by (c) 2ay – b (d) b – 2ay

41. A particle, which is constrained to move along the x-axis, is subjected to a force in the same direction which varies with the distance x of the particle from the origin as $F(x) = -kx + ax^3$. Here k and a are positive constants. For $x \geq 0$, the functional form of the potential energy $U(x)$ of the particle is

(a) 

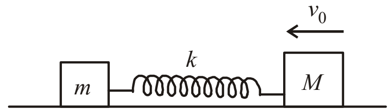
(b) 

(c) 

(d) 

42. Two blocks of masses m and M are joined with an ideal spring of spring constant k and kept on a rough surface as shown. The spring is initially unstretched and the coefficient of friction between the blocks and the horizontal surface is μ. What should be the maximum speed of the block of mass M such that the smaller block does not move?

Critical Thinking



(a) $\mu g\sqrt{\frac{Mm}{(M+m)k}}$ (b) $\mu g\sqrt{\frac{(M+m)k}{Mm}}$

(c) $\mu g\sqrt{\frac{(2M+m)m}{kM}}$ (d) None of these

43. Two blocks of masses $m_1 = 10$ kg and $m_2 = 20$ kg are connected by a spring of stiffness $k = 200$N/m. The coefficient of friction between the blocks and the fixed horizontal surface is μ = 0.1. Find the minimum constant horizontal force F (in newtons) to be applied to m_1 in order to slide the mass m_2. [Take $g = 10$ m/s^2]

(a) $\mu m_1 g + \frac{\mu m_2 g}{2}$ (b) $\mu m_1 g + \mu m_2 g$

(c) $\mu m_1 g - \frac{\mu m_2 g}{2}$ (d) $\frac{\mu m_1 g + \mu m_2 g}{2}$

44. A body of mass m is accelerated uniformly from rest to a speed v in a time T. The instantaneous power delivered to the body as a function of time is given by

(a) $\frac{mv^2}{T^2}.t^2$ (b) $\frac{mv^2}{T^2}.t$

(c) $\frac{1}{2}\frac{mv^2}{T^2}.t^2$ (d) $\frac{1}{2}\frac{mv^2}{T^2}.t$

45. A car of mass m starts from rest and accelerates so that the instantaneous power delivered to the car has a constant magnitude p_o. The instantaneous velocity of this car is proportiourl to:

(a) $t^2 p_o$ (b) $t^{1/2}$ (c) $t^{-1/2}$ (d) $\frac{t}{\sqrt{m}}$

46. How much water, a pump of 2 kW can raise in one minute to a height of 10 m, take g = 10 m/s^2?

(a) 1000 (b) 1200 (c) 100 (d) 2000

47. The engine of a vehicle delivers constant power. If the vehicle is moving up the inclined plane then, its velocity,

(a) must remain constant
(b) must increase
(c) must decrease
(d) may increase, decrease or remain same.

48. A body is moved along a straight line by a machine delivering a constant power. The distance moved by the body in time 't' is proportional to Tricky

(a) $t^{3/4}$ (b) $t^{3/2}$
(c) $t^{1/4}$ (d) $t^{1/2}$

49. A body projected vertically from the earth reaches a height equal to earth's radius before returning to the earth. The power exerted by the gravitational force is greatest

(a) at the highest position of the body
(b) at the instant just before the body hits the earth
(c) it remains constant all through
(d) at the instant just after the body is projected

50. A body of mass 10 kg moves with a velocity v of 2 m/s along a circular path of radius 8 m. The power produced by the body will be

(a) 10 J/s (b) 98 J/s (c) 49 J/s (d) zero

51. A small block of mass 200g is kept at the top of a an incline which is 10 m long and 3.2 m high. Match the columns

	Column I	Column II
(A)	Work done, to lift the block from the ground and put it at the top	(1) 6.3 J
(B)	Work done to slide the block up the incline	(2) 7.2 J
(C)	the speed of the block at the ground when left from the top of the incline to fall vertically	(3) 8 m/s
(D)	The speed of the block at the ground when slide along the incline	(4) 4 m/s

(a) (A)→(2); (B)→(3); (C)→(1); (D)→(4)
(b) (A)→(1); (B)→(1); (C)→(3); (D)→(3)
(c) (A)→(4); (B)→(3); (C)→(2); (D)→(2)
(d) (A)→(1); (B)→(3); (C)→(1); (D)→(2)

52. If two persons A and B take 2 seconds and 4 seconds respectively to lift an object to the same height h, then the ratio of their powers is

(a) 1 : 2 (b) 1 : 1 (c) 2 : 1 (d) 1 : 3

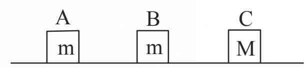
53. A 10 H.P. motor pumps out water from a well of depth 20 m and fills a water tank of volume 22380 litres at a height of 10 m from the ground. The running time of the motor to fill the empty water tank is ($g = 10ms^{-2}$)

(a) 5 minutes (b) 10 minutes
(c) 15 minutes (d) 20 minutes

54. If a machine gun fires n bullets per second each with kinetic energy K, then the power of the machine gun is

(a) nK^2 (b) $\frac{K}{n}$ (c) n^2K (d) nK

55. There block A, B and C are lying on a smooth horizontal surface, as shown in the figure. A and B have equal masses, m while C has mass M. Block A is given an inital speed v towards B due to which it collides with B perfectly inelastically. The combined mass collides with C, also perfectly inelastically $\frac{5}{6}$th of the initial kinetic energy is lost in whole process. What is value of M/m?



(a) 5 (b) 2 (c) 4 (d) 3

56. A block of mass 1.9 kg is at rest at the edge of a table, of height 1 m. A bullet of mass 0.1 kg collides with the block and sticks to it. If the velocity of the bullet is 20 m/s in the horizontal direction just before the collision then the kinetic energy just before the combined system strikes the floor, is [Take $g = 10\ m/s^2$. Assume there is no rotational motion and losss of energy after the collision is negligiable.]

(a) 20 J (b) 21 J (c) 19 J (d) 23 J

57. A force applied by an engine of a train of mass 2.05×10^6 kg changes its velocity from 5m/s to 25 m/s in 5 minutes. The power of the engine is

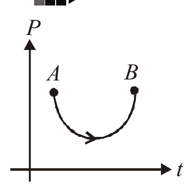
(a) 1.025 MW (b) 2.05 MW
(c) 5 MW (d) 6 MW

58. A 10 m long iron chain of linear mass density 0.8 $kg\ m^{-1}$ is hanging freely from a rigid support. If $g = 10\ ms^{-2}$, then the power required to left the chain upto the point of support in 10 second

(a) 10 W (b) 20W (c) 30 W (d) 40 W

59. The net power of all the forces acting on a particle (P) versus time curve is shown. Work done upon the particle from A to B Tricky

(a) increases
(b) decreases
(c) first increases then decreases
(d) first decreases then increases



60. A wind-powered generator converts wind energy into electrical energy. Assume that the generator converts a fixed fraction of the wind energy intercepted by its blades into electrical energy. For wind speed v, the electrical power output will be proportional to

(a) v (b) v^2
(c) v^3 (d) v^4

61. A body of mass 1 kg begins to move under the action of a time dependent force $\vec{F}=(2t\hat{i}+3t^2\hat{j})$ N, where $\hat{i}$ and $\hat{j}$ are unit vectors alogn x and y axis. What power will be developed by the force at the time t?

(a) $(2t^2 + 3t^3)$W (b) $(2t^2 + 4t^4)$W
(c) $(2t^3 + 3t^4)$ W (d) $(2t^3 + 3t^5)$W

62. The energy content of gasoline is 3.6×10^7 J/L. A motor with an efficiency of 20% is needed at full output power of 45kW for 50.0 minutes. How many litres of gasoline are required to operate the motor for this amount of time ?

(a) 0.31 L (b) 0.38 L (c) 1.6 L (d) 19 L

63. If the Kinetic energy of a moving body becomes four times its initial Kinetic energy, then the percentage change in its momentum will be :

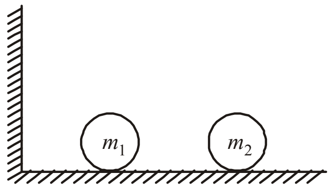
(a) 100% (b) 200%
(c) 300% (d) 400%

64. An iron ball of mass m, suspended by a light inextensible string of length ℓ from a fixed point O, is shifted by an angle θ_0 as shown so as to strike the vertical wall perpendicularly. The maximum angle made by the string with vertical after the first collision, if e is the coefficient of restitution, is

(a) $\sin^{-1}\{1-e^2(1-\cos\theta_0)\}$
(b) $\cos^{-1}\{1-e^2(1-\cos\theta_0)\}$
(c) $\tan^{-1}\{1-e^2(1-\cos\theta_0)\}$
(d) zero

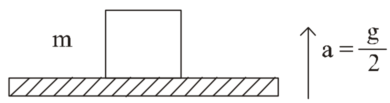
65. Mass m_1 strikes m_2 which is at rest. The ratio of masses for which they will collide again (collision between ball and wall are elastic, coefficient of restitution between m_1 and m_2 is e and all the surfaces are smooth.)

Tricky



(a) $< \dfrac{e}{2+e}$
(b) $> \dfrac{2e}{2+e}$
(c) $\geq \dfrac{e}{2(2+e)}$
(d) None of the above

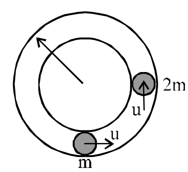
66. A block of mass m is kept on a platform which starts from rest with constant acceleration g/2 upward, as shown in fig. work done by normal reaction on block in time t is:



(a) $-\dfrac{mg^2t^2}{8}$ (b) $\dfrac{mg^2t^2}{8}$
(c) 0 (d) $\dfrac{3mg^2t^2}{8}$

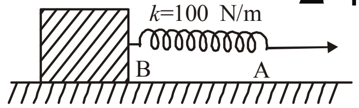
67. Two small bodies of masses 'm' and '2m' are placed in a fixed smooth horizontal circular hollow tube of mean radius 'r' as shown. The mass 'm' is moving with speed 'u' and the mass '2m' is stationary. After their first collision, the time elapsed for next collision is [coefficient of restitution e = 1/2]

(a) $\dfrac{2\pi r}{u}$ (b) $\dfrac{4\pi r}{u}$
(c) $\dfrac{3\pi r}{u}$ (d) $\dfrac{12\pi r}{u}$



68. A block lying on a smooth surface with spring connected to it is pulled by an external force as shown. Initially the velocity of ends A and B of the spring are 4 m/s and 2 m/s respectively. If the energy of the spring is increasing at the rate of 20 J/sec, then the stretch in the spring is

Critical Thinking

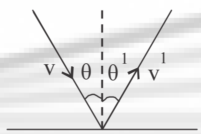


(a) 1.0 cm (b) 2.0 cm
(c) 10 cm (d) 2.0 cm

69. A car of weight W is on an inclined road that rises by 100 m over a distance of 1 Km and applies a constant frictional force $\frac{W}{20}$ on the car. While moving uphill on the road at a speed of 10 ms^{-1}, the car needs power P. If it needs power $\frac{P}{2}$ while moving downhill at speed v then value of v is:
(a) 20 ms^{-1} (b) 5 ms^{-1} (c) 15 ms^{-1} (d) 10 ms^{-1}

70. A ball of mass m hits the floor making an angle θ as shown in the figure. If e is the coefficient of restitution, then which relation is true, for the velocity component before and after collision?

Tricky

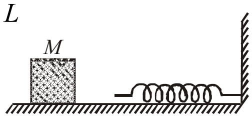


(a) $V^1 \sin\theta' = V \sin\theta$
(b) $V^1 \sin\theta' = -\sin\theta$
(c) $V^1 \cos\theta' = V \cos\theta$
(d) $V^1 \cos\theta' = -V \cos\theta$

71. A rubber ball is dropped from a height of 5m on a plane, where the acceleration due to gravity is not shown. On bouncing it rises to 1.8 m. The ball loses its velocity on bouncing by a factor of
(a) $\frac{16}{25}$ (b) $\frac{2}{5}$ (c) $\frac{3}{5}$ (d) $\frac{9}{25}$

72. A man (mass = 50 kg) and his son (mass = 20 kg) are standing on a frictionless surface facing each other. The man pushes his son so that he starts moving at a speed of 0.70 ms^{-1} with respect to the man. The speed of the man with respect to the surface is :
(a) 0.28 ms^{-1} (b) 0.20 ms^{-1}
(c) 0.47 ms^{-1} (d) 0.14 ms^{-1}

73. The block of mass M moving on the frictionless horizontal surface collides with the spring of spring constant k and compresses it by length L. The maximum momentum of the block after collision is
(a) $\frac{kL^2}{2M}$ (b) $\sqrt{Mk}\ L$
(c) $\frac{ML^2}{k}$ (d) zero



74. A bullet of mass 20g and moving with 600 m/s collides with a block of mass 4 kg hanging with the string. What is velocity of bullet when it comes out of block, if block rises to height 0.2 m after collision ?

Critical Thinking

(a) 200 m/s (b) 150 m/s
(c) 400 m/s (d) 300 m/s

75. A block of mass 0.50 kg is moving with a speed of 2.00 ms^{-1} on a smooth surface. It strikes another mass of 1.00 kg and then they move together as a single body. The energy loss during the collision is
(a) 0.16 J (b) 1.00 J (c) 0.67 J (d) 0.34 J

76. **Statement I :** If collision occurs between two elastic bodies their kinetic energy decreases during the time of collision.

Statement II : During collision intermolecular space decreases and hence elastic potential energy increases.

(a) Both statement I and II are correct.
(b) Both statement I and II are incorrect.
(c) Statement I is correct but statement II is incorrect.
(d) Statement II is correct but statement I is incorrect.

77. An engine is hauling a train of mass M kg on a level track at a constant speed v m/s. The resistance due to friction is f N / kg. What extra power must the engine develop to maintain the speed up a gradient of h in s :
(a) $\frac{Mghv}{s}$ (b) $\frac{Mghs}{v}$ (c) $Mghvs$ (d) zero

78. An electric pump is used to fill an overhead tank of capacity 9m^3 kept at a height of 10m above the ground. If the pump takes 5 minutes to fill the tank by consuming 10 kW power the efficiency of the pump should be (g = 10 ms^{-2})
(a) 60% (b) 40% (c) 20% (d) 30%

79. Water falls from a height of 60 m at the rate of 15 kg/s to operate a turbine. The losses due to frictional force are 10% of energy. How much power is generated by the turbine?(g = 10 m/s^2)
(a) 8.1 kW (b) 10.2 kW
(c) 12.3 kW (d) 7.0 kW

80. A particle of mass m is moving in a circular path of constant radius r such that its centripetal acceleration a_c is varying with time t as $a_c = k^2rt^2$ where k is a constant. The power delivered to the particles by the force acting on it is

Critical Thinking

(a) $2\pi\ mk^2r^2\ t$ (b) mk^2r^2t

(c) $\dfrac{(mk^4r^2t^5)}{3}$ (d) zero

81. A particle of mass 'm' is moving with speed '$2v$' and collides with a mass '$2m$' moving with speed 'v' in the same direction. After collision, the first mass is stopped completely while the second one splits into two particles each of mass 'm', which move at angle 45° with respect to the original direction.

The speed of each of the moving particle will be:

(a) $\sqrt{2}\ v$ (b) $2\sqrt{2}\ v$

(c) $v/(2\sqrt{2})$ (d) $v/\sqrt{2}$

82. A particle falls from a height h on a fixed horizontal plane and rebounds. If e is the coefficient of restitution, the total distance travelled by the particle before it stops rebounding is

Toughnut

(a) $\dfrac{h}{2}\dfrac{[1-e^2]}{[1+e^2]}$ (b) $\dfrac{h[1-e^2]}{[1+e^2]}$

(c) $\dfrac{h}{2}\dfrac{[1+e^2]}{[1-e^2]}$ (d) $\dfrac{h[1+e^2]}{[1-e^2]}$

83. A collision occurs between two identical balls of mass m each, moving with velocities $\vec{u}_1$ and $\vec{u}_2$. If the collision is head on and the energy lost in the collision is $\Delta E = \dfrac{3}{16}\left(\vec{u}_1 - \vec{u}_2\right)^2$ then the coefficient of restitution is

(a) 0.25 (b) 0.75 (c) 0.5 (d) 0.9

84. A shell is fired from a cannon with a velocity v (m/sec.) at an angle θ with the horizontal direction. At the highest point in its path it explodes into two pieces of equal mass. One of the pieces retraces its path to the cannon and the speed (in m/sec.) of the other piece immediately after the explosion is

Critical Thinking

(a) $3v\cos\theta$ (b) $2v\cos\theta$

(c) $\dfrac{3}{2}v\cos\theta$ (d) $\sqrt{\dfrac{3}{2}}v\cos\theta$

85. An object of mass m is projected vertically upwards with a speed of v_0. At the same moment another object of mass M, which is initially above the projected one, is dropped from a height of h. The two point like objects collide completely inelastically, and they stick to each other. Find kinetic energy (in J) of combined mass just before it hits the ground. (Given : $m = 1$ kg, $v_0 = 20$ m/s, $M = 3$ kg, $h = 20$m, $g = 10$ m/s^2).

Toughnut

(a) 550 J (b) 650 J (c) 450 J (d) 250 J

86. **Statement I :** When the force retards the motion of a body, the work done is zero.

Statement II : Work done depends on angle between force and displacement.

(a) Both statement I and II are correct.
(b) Both statement I and II are incorrect.
(c) Statement I is correct but statement II is incorrect.
(d) Statement II is correct but statement I is incorrect.

87. **Assertion :** Work done by friction on a body sliding down an inclined plane is positive.

Reason : Work done is greater than zero, if angle between force and displacement is acute or both are in same direction.

(a) If both Assertion and Reason are correct and the Reason is a correct explanation of the Assertion.
(b) If both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion.
(c) If the Assertion is correct but Reason is incorrect.
(d) If the Assertion is incorrect and Reason is correct.

88. If W represents the work done, then match the two columns:

	Column I		Column II
(A)	Force is always along the velocity	(1)	$W = 0$
(B)	Force is always perpendicular to velocity	(2)	$W < 0$
(C)	Force is always perpendicular to acceleration	(3)	$W > 0$
(D)	The object is stationary but the point of application of the force moves on the object		

(a) (A)→(1); (B)→(2); C→(3); (D)→(2)
(b) (A)→(3); (B)→(1); C→(2,3); (D)→(1)
(c) (A)→(2); (B)→(3); C→(1); (D)→(2)
(d) (A)→(1); (B)→(2); C→(3); (D)→(1)

89. Statement I : A block of mass *m* starts moving on a rough horizontal surface with a velocity *v*. It stops due to friction between the block and the surface after moving through a certain distance. The surface is now tilted to an angle of 30° with the horizontal and the same block is made to go up on the surface with the same initial velocity *v*. The decrease in the mechanical energy in the second situation is smaller than that in the first situation.

Statement II : The coefficient of friction between the block and the surface decreases with the increase in the angle of inclination.

(a) Both statement I and II are correct.
(b) Both statement I and II are incorrect.
(c) Statement I is correct but statement II is incorrect.
(d) Statement II is correct but statement I is incorrect.

90. Consider the following statements

I. The slope of kinetic energy-displacement curve of a body in motion will be directly proportional to its acceleration.

II. From a height of 15 m a ball is projected vertically upwards with a velocity of 30 m/s. If the ball rises to the same height after hitting the ground, the loss of its energy on hitting the ground is 30%.

III. The velocity acquired by a body of mass 'm' after travelling a fixed distance from rest under the action of a constant force is directly proportional to mass 'm'.

Which of the following is correct?

(a) I only (b) II only
(c) I and II (d) II and III

91. Statement I : Power is directly proportional to work done.

Statement II : Power is related to force and velocity.

(a) Both statement I and II are correct.
(b) Both statement I and II are incorrect.
(c) Statement I is correct but statement II is incorrect.
(d) Statement II is correct but statement I is incorrect.

92. I. Power can be expressed in terms of force $\vec{F}$ and velocity $\vec{v}$.

II. Power can be expressed as $P = \dfrac{W}{t^2}$.

III. Power is the amount of energy transferred per unit time.

Identify correct statements :

(a) I and III (b) Only II
(c) I, II and III (d) None of these

93. Assertion : Power developed in circular motion is always zero.

Reason : Work done in case of circular motion is zero.

(a) If both Assertion and Reason are correct and the Reason is a correct explanation of the Assertion.
(b) If both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion.
(c) If the Assertion is correct but Reason is incorrect.
(d) If the Assertion is incorrect and Reason is correct.

94. Statement I : In an elastic collision between two bodies, the relative speed of the bodies after collision is equal to the relative speed before the collision.

Statement II : In an elastic collision, the linear momentum of the system is conserved.

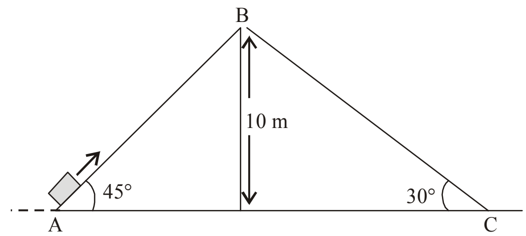
(a) Both statement I and II are correct.
(b) Both statement I and II are incorrect.
(c) Statement I is correct but statement II is incorrect.
(d) Statement II is correct but statement I is incorrect.

95. **Assertion :** The conservation of kinetic energy in elastic collision applies after the collision is over and does not hold at every instant of the collision.
Reason: During a collision the total linear momentum is conserved at each instant of the collision.
(a) If both Assertion and Reason are correct and the Reason is a correct explanation of the Assertion.
(b) If both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion.
(c) If the Assertion is correct but Reason is incorrect.
(d) If the Assertion is incorrect and Reason is correct.

Numeric Value Questions

96. Two persons A and B perform same amount of work in moving a body through a certain distance d with application of forces acting at angle 45° and 60° with the direction of displacement respectively. The ratio of force applied by person A to the force applied by person B is $\frac{1}{\sqrt{x}}$. The value of x is _________ .

97. Two inclined planes are placed as shown in figure. A block is projected from the Point A of inclined plane AB along its surface with a velocity just sufficient to carry it to the top Point B at a height 10 m. After reaching the Point B the block slides down on inclined plane BC. Time it takes to reach to the point C from point A is $t\left(\sqrt{2}+1\right)$ s. The value of t is ______ (use g = 10 m/s^2)



98. A body A, of mass $m = 0.1$ kg has an initial velocity of $3\,\hat{i}$ ms^{-1}. It collides elastically with another body, B of the same mass which has an initial velocity of $5\,\hat{j}$ ms^{-1}. After collision, A moves with a velocity $\vec{v} = 4\left(\hat{i}+\hat{j}\right)$. The energy of B after collision is written as $\frac{x}{10}$ J. The value of x is _______.

99. A body of mass 2 kg is driven by an engine delivering a constant power of 1 J/s. The body starts from rest and moves in a straight line. After 9 seconds, the body has moved a distance (in m) ________.

100. An engine is attached to a wagon through a shock absorber of length 1.5 m. The system with a total mass of 40,000 kg is moving with a speed of 72 kmh^{-1} when the brakes are applied to bring it to rest. In the process of the system being brought to rest, the spring of the shock absorber gets compressed by 1.0 m. If 90% of energy of the wagon is lost due to friction, the spring constant is _______ $\times 10^5$ N/m.

ANSWER KEY

1	(b)	**11**	(c)	**21**	(c)	**31**	(c)	**41**	(d)	**51**	(b)	**61**	(d)	**71**	(b)	**81**	(b)	**91**	(a)
2	(a)	**12**	(b)	**22**	(b)	**32**	(b)	**42**	(c)	**52**	(c)	**62**	(d)	**72**	(b)	**82**	(d)	**92**	(a)
3	(c)	**13**	(d)	**23**	(b)	**33**	(a)	**43**	(a)	**53**	(c)	**63**	(a)	**73**	(b)	**83**	(c)	**93**	(a)
4	(c)	**14**	(c)	**24**	(a)	**34**	(a)	**44**	(b)	**54**	(d)	**64**	(b)	**74**	(a)	**84**	(a)	**94**	(a)
5	(c)	**15**	(c)	**25**	(b)	**35**	(b)	**45**	(b)	**55**	(c)	**65**	(a)	**75**	(c)	**85**	(b)	**95**	(b)
6	(b)	**16**	(a)	**26**	(a)	**36**	(d)	**46**	(b)	**56**	(b)	**66**	(d)	**76**	(b)	**86**	(a)	**96**	(2)
7	(c)	**17**	(c)	**27**	(c)	**37**	(d)	**47**	(a)	**57**	(b)	**67**	(b)	**77**	(a)	**87**	(d)	**97**	(2)
8	(a)	**18**	(a)	**28**	(c)	**38**	(d)	**48**	(b)	**58**	(d)	**68**	(c)	**78**	(d)	**88**	(b)	**98**	(1)
9	(d)	**19**	(d)	**29**	(a)	**39**	(b)	**49**	(b)	**59**	(a)	**69**	(c)	**79**	(a)	**89**	(c)	**99**	(18)
10	(b)	**20**	(b)	**30**	(c)	**40**	(d)	**50**	(d)	**60**	(c)	**70**	(a)	**80**	(b)	**90**	(a)	**100**	(16)

Hints & Solutions

1. **(b)** Applying momentum conservation

$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$

$0.1u + m(0) = 0.1(0) + m(3)$

$0.1u = 3m;\ \frac{1}{2}0.1u^2 = \frac{1}{2}m(3)^2$

Solving we get, $u = 3$

$\frac{1}{2}kx^2 = \frac{1}{2}K\left(\frac{x}{2}\right)^2 + \frac{1}{2}(0.1)3^2$

$\Rightarrow \quad \frac{3}{4}kx^2 = 0.9 \Rightarrow \frac{3}{2}\times\frac{1}{2}kx^2 = 0.9$

$\therefore \quad \frac{1}{2}Kx^2 = 0.6$ J

(total initial energy of the spring)

2. **(a)** Work done against gravity = $mg \sin\theta \times d$

$= 2\times 10\times 10 = 200$ J $(d \sin\theta = 10)$

Actual work done = 300 J

Work done against friction = 300 – 200 = 100 J

3. **(c)** By work-energy theorem,

$\Delta k = W_{\text{all forces}} = \int \vec{F}.\,d\vec{r}$

$= \int (4x\hat{i} + 3y^2\hat{j}).(dx\hat{i} + dy\,\hat{j})$

$= \int_1^2 4x\,dx + \int_2^3 3y^2 dy = 4\left[\frac{x^2}{2}\right]_1^2 + 3\left[\frac{y^3}{3}\right]_2^3$

$= 2[2^2 - 1^2] + [3^3 - 2^3] = 6 + 19 = 25$ J.

4. **(c)** From given graph :

$\vec{F} = \left(\frac{3}{4}x + 10\right)\hat{i} + \left(20 - \frac{4}{3}y\right)\hat{j} + \left(\frac{4}{3}z - 16\right)\hat{k}$

$W = \int \vec{F}\cdot\vec{ds}$

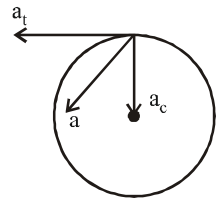
$= \int_{(0,5,6)}^{(2,10,0)} \left(\frac{3}{4}x + 10\right)\hat{i} + \left(20 - \frac{4}{3}y\right)\hat{j} + \left(\frac{4}{3}z - 16\right)\hat{k}$

$[dx\,\hat{i} + dy\,\hat{j} + dz\,\hat{k}] = \frac{287}{2}$ J

Work done can also be found by finding area under these curves.

5. **(c)** $a_c = k^2rt^2 = \frac{v^2}{r} \Rightarrow v = krt$

$a_t = \frac{dv}{dt} = kr$



Now, $P = (\vec{F}_r + \vec{F}_t).\,\vec{v}$

$= 0 + F_tv = ma_tv$

$= mkr\,(krt) = mk^2r^2t$

6. **(b)** Energy required = mgh

In both cases, h is the same. Hence energy both is the same.

7. **(c)** Initial momentum $(p_1) = p$; Final momentum $(p_2) = 1.5$ p and initial kinetic energy $(K_1) = K$.

Kinetic energy $(K) = \frac{p^2}{2m} \propto p^2$

or, $\frac{K_1}{K_2} = \left(\frac{p_1}{p_2}\right)^2 = \left(\frac{p}{1.5p}\right)^2 = \frac{1}{2.25}$

or, $K_2 = 2.25\,K$.

Therefore, increase in kinetic energy is $2.25\,K - K = 1.25\,K$ or 125%.

8. **(a)** $U_1 = mgh_1$ and $U_2 = mgh_2$

% energy lost = $\frac{U_1 - U_2}{U_1}\times 100$

$= \frac{mgh_1 - mgh_2}{mgh_1}\times 100 = \left(\frac{h_1 - h_2}{h_1}\right)\times 100$

$= \frac{2 - 1.5}{2}\times 100 = 25\%$

9. **(d)** Work done on the body is gain in the kinetic energy. Acceleration of the body is a = V/T.

Velocity acquired in time t is v = at $= \frac{V}{T}t$

K.E. acquired $\propto v^2$. That is work done $\propto \frac{V^2t^2}{T^2}$

10. **(b)** Total force required to lift maximum load capacity against frictional force = 400 *N*
$F_{total} = Mg + \text{friction}$
$= 2000 \times 10 + 4000 = 20{,}000 + 4000 = 24000\,N$
Using power, $P = F \times v$
$60 \times 746 = 24000 \times v \Rightarrow v = 1.86$ m/s ≈ 1.9 *m/s*
Hence speed of the elevator at full load is close to $1.9\ ms^{-1}$

11. **(c)** Let m = mass of boy, M = mass of man
v = velocity of boy, V = velocity of man

$$\frac{1}{2}MV^2 = \frac{1}{2}\left[\frac{1}{2}mv^2\right] \quad ...(i)$$

$$\frac{1}{2}M(V+1)^2 = 1\left[\frac{1}{2}mv^2\right] \quad ...(ii)$$

Putting $m = \frac{M}{2}$ and solving $V = \frac{1}{\sqrt{2}-1}$

12. **(b)** $v^2 = u^2 + 2gh = (10)^2 + 2\times 10\times 19.5 = 490$
K.E. at the ground

$$= \frac{1}{2}mv^2 = \frac{1}{2}\times\frac{5}{1000}\times 490 = \frac{49}{40}\text{ J}$$

$$\text{P.E.} = mgh = \frac{5}{1000}\times 10\times\left(\frac{-50}{100}\right) = -\frac{1}{40}\text{ J}$$

$$\therefore \quad \text{Change in energy} = \frac{49}{40} - \left(-\frac{1}{40}\right)$$

$$= \frac{50}{40} = 1.25\text{J}$$

13. **(d)**

14. **(c)** $U = (1/2)Mv^2$

15. **(c)** Let *E* be the total energy then

$$\frac{P.E}{K.E} = \frac{mgh}{E - mgh} = \frac{2}{3} \Rightarrow E = \frac{5}{2}\text{ mgh}$$

When velocity is double then inital energy becomes 4*E*.

$$\text{So, } \frac{mgh}{4E - mgh} = NL = \frac{mgh}{10mgh - mgh}$$

On solving we get $\frac{P.E}{K.E} = \frac{1}{9}$.

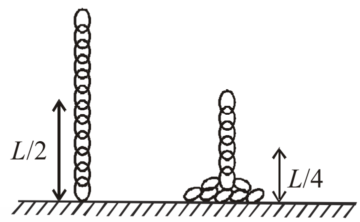
16. **(a)** $U_1 = \int_0^{\ell/3} -\frac{m}{\ell}gx\,dx = -\frac{1}{18}mg\ell;$

$$U_2 = \int_0^{\ell} -\frac{m}{\ell}gx\,dx = -\frac{1}{2}mg\ell$$

$$\text{loss in P.E.} = U_1 - U_2 = \frac{4}{9}\text{mgl}$$

$$= \frac{4}{9}\times 0.1\times 10\times 2 = \frac{8}{9}\text{J} = \text{Final K.E.}$$

17. **(c)** The work done by man is negative of magnitude of decreases in potential energy of chain



$$\Delta U = mg\frac{L}{2} - \frac{m}{2}g\frac{L}{4} = 3mg\frac{L}{8} \quad \therefore\ W = -\frac{3mgL}{8}$$

18. **(a)** Given: Mass of particle, $M = 10\text{g} = \frac{10}{1000}$kg
radius of circle R = 6.4 cm
Kinetic energy E of particle $= 8 \times 10^{-4}$J
acceleration $a_t = ?$

$$\frac{1}{2}mv^2 = E \Rightarrow \frac{1}{2}\left(\frac{10}{1000}\right)v^2 = 8\times 10^{-4}$$

$$\Rightarrow v^2 = 16\times 10^{-2} \Rightarrow v = 4\times 10^{-1} = 0.4\text{ m/s}$$

Now, using
$v^2 = u^2 + 2a_t s \quad (s = 4\pi R)$

$$(0.4)^2 = 0^2 + 2a_t\left(4\times\frac{22}{7}\times\frac{6.4}{100}\right)$$

$$\Rightarrow \quad a_t = (0.4)^2 \times \frac{7\times 100}{8\times 22\times 6.4} = 0.1\text{ m/s}^2$$

19. **(d)** Before collision,
Velocity of particle *A*, $u_1 = (\sqrt{3}\hat{i} + \hat{j})$ m/s
Velocity of particle *B*, $u_2 = 0$
After collision,
Velocity of particle *A*, $v_1 = (\hat{i} + \sqrt{3}\hat{j})$
Velocity of particle *B*, $v_2 = 0$
Using principal of conservation of angular momentum

$$m_1\vec{u}_1 + m_2\vec{u}_2 = m_1\vec{v}_1 + m_2\vec{v}_2$$

$$\Rightarrow 2m_2(\sqrt{3}\hat{i} + \hat{j}) + m_2\times 0 = 2m_2(\hat{i} + \sqrt{3}\hat{j}) + m_2\times\vec{v}_2$$

$\Rightarrow 2\sqrt{3}\hat{i} + 2\hat{j} = 2\hat{i} + 2\sqrt{3}\hat{j} + \vec{v}_2$

$\Rightarrow \vec{v}_2 = \left[(\sqrt{3}-1)\hat{i} - (\sqrt{3}-1)\hat{j}\right] \times 2$

$\Rightarrow \vec{v}_1 = \hat{i} + \sqrt{3}\hat{j}$

For angle between $\vec{v}_1$ and $\vec{v}_2$,

$$\cos\theta = \frac{\vec{v}_1 \cdot \vec{v}_2}{\vec{v}_1 \vec{v}_2} = \frac{2(\sqrt{3}-1)(1-\sqrt{3})}{2 \times 2\sqrt{2}(\sqrt{3}-1)} = \frac{1-\sqrt{3}}{2\sqrt{2}}$$

$\Rightarrow \theta = 105°$

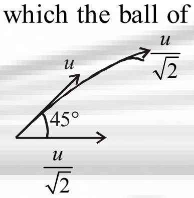
Angle between $\vec{v}_1$ and $\vec{v}_2$ is 105°

20. **(b)** $J = m(v_f - v_i)$ or $7.5 = 15(v_f - 0)$

$\Rightarrow v_f = 0.5$ m/s

$\therefore \quad K = \frac{1}{2}mv^2 = \frac{1}{2} \times 15 \times 0.5^2 = 1.9\,\text{J}$

21. **(c)** Let u be the speed with which the ball of mass m is projected.
Then the kinetic energy (E) at the point of projection is



$E = \frac{1}{2}mu^2$ ...(i)

When the ball is at the highest point of its flight, the speed of the ball is $\frac{u}{\sqrt{2}}$ (Remember that the horizontal component of velocity does not change during a projectile motion).

$\therefore$ The kinetic energy at the highest point

$$= \frac{1}{2}m\left(\frac{u}{\sqrt{2}}\right)^2 = \frac{1}{2}\frac{mu^2}{2} = \frac{E}{2} \quad \text{[From (i)]}$$

22. **(b)** From work-energy theorem,
$W_{Porter} + W_{mg} = \Delta K.E. = 0$ ($\because$ velocity constant)

or, $W_{Porter} = -W_{mg} = -mgh$

$\therefore \quad W_{Porter} = -80 \times 9.8 \times \frac{80}{100} = -627.2\,\text{J}$

23. **(b)** $W_{gravity} + W_F = \Delta K$

$-10 \times g(10 - 10\cos 60°) + 200 \times 10 \sin 60°$

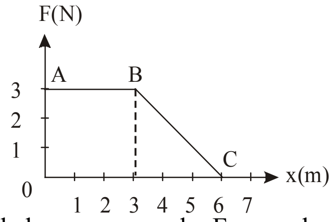
$= \frac{1}{2} \times 10 \times v_f^2 - 0 \quad \therefore \quad v_f = 17$ m/s

24. **(a)** Net displacement is $(3\hat{i} + 3\hat{j})$

so work done $= \vec{F}.\Delta\vec{s} = 11.25(\hat{i} + \hat{j}).(3\hat{i} + 3\hat{j})$

$= 33.75 \times 2 = 67.50$ J

25. **(b)**



Work done = area under F-x graph

$= \text{area of trapezium OABC} = \frac{1}{2}(3+6)(3) = 13.5\,\text{J}$

26. **(a)** W = F s cos 90º = zero

27. **(c)** W = area of $F - x$ graph
= area of Δ + area of rectangle + area of Δ

$= \frac{5 \times 3}{2} + 10 \times 3 + \frac{5 \times 3}{2} = 45\ J$

28. **(c)** As the cord is trying to hold the motion of the block, work done by the cord is negative.

$$W = -M(g-a)\,d = -M\left(g - \frac{g}{4}\right)d = \frac{-3Mgd}{4}$$

29. **(a)** $W_1 = \frac{1}{2} \times 5 \times 10^3 (0.05)^2$

$\Rightarrow W_2 = \frac{1}{2} \times 5 \times 10^3 (0.10)^2$

$\therefore \quad \Delta W = \frac{1}{2} \times 5 \times 10^3 \times 0.15 \times 0.05 = 18.75\text{J}.$

30. **(c)** here, m = 4, g = 4×10^{-3} kg

$x = 4t^2 + t \quad \therefore \frac{dx}{dt} = 8t + 1 \quad \frac{d^2x}{dt^2} = 8$

Work done, $W = \int f dx = \int m \frac{d^2x}{dt^2}\left(\frac{dx}{dt}\right)dt$

$= \int_0^2 (4 \times 10^{-3})(8)(8t+1)\,dt$

$= 32 \times 10^{-3} \int_0^2 (8t+1)dt = 32 \times 10^{-3}\left[\frac{8t^2}{2} + t\right]_0^2$

$= 32 \times 10^{-3} [4(2)^2 + 2 - 0] = 576$ mJ

31. **(c)** $W = F s \cos\theta, \ \cos\theta = \frac{W}{Fs} = \frac{25}{5 \times 10} = \frac{1}{2},$

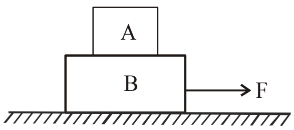
$\theta = 60$º.

32. **(b)** In the frame of lift displacement is zero, so W = F.S = T.S = 0.

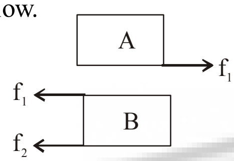
33. (a) $W = \int_{x_1}^{x_2} F dx = \int_{4}^{-2} -6x^3 dx$

$= -6\left|\frac{x^4}{4}\right|_4^{-2} = \frac{-6}{4}[(-2)^4 - (4)^2] = 360\text{ J.}$

34. (a) Consider the blocks shown in the figure to be moving together due to friction between them.



The free body diagrams of both the blocks are shown below.



Work done by static friction on A is positive and on B is negative

35. (b) Total energy at the time of projection

$= \frac{1}{2}mv^2 = \frac{1}{2} \times 0.1(20)^2 = 20\text{J}$

Half way up, P.E. becomes half the P.E. at the top

i.e. $\text{P.E.} = \frac{20}{2} = 10\text{J}$

$\therefore$ K.E. = 20 – 10 = 10J.

36. (d) Given, $\frac{dk}{dt}$ = constant

$\Rightarrow \quad k \propto t \;\Rightarrow\; v \propto \sqrt{t}$

Also, $P = Fv = \frac{dk}{dt}$ = constant

$\Rightarrow \quad F \propto \frac{1}{v} \;\Rightarrow\; F \propto \frac{1}{\sqrt{t}}$

37. (d) Kinetic energy of a body,

$K = \frac{p^2}{2m}$

As $p_1 = p_2$ (Given)

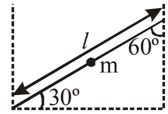
$\therefore \frac{K_1}{K_2} = \frac{m_2}{m_1} = \frac{5}{4}$

38. (d) For any uniform rod, the mass is supposed to be concentrated at its centre.

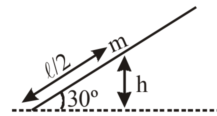
$\therefore$ height of the mass from ground is, $h = (l/2)\sin 30^\circ$

$\therefore$ Potential energy of the rod

$= m \times g \times \frac{\ell}{2} \sin 30^\circ$



$= m \times g \times \frac{\ell}{2} \times \frac{1}{2} = \frac{mg\ell}{4}$



39. (b) Let the blow compress the spring by x before stopping.

Kinetic energy of the block = (P.E of compressed spring) + work done against function.

$\frac{1}{2} \times 2 \times (4)^2 = \frac{1}{2} \times 10{,}000 \times x^2 + (+15) \times x$

$10{,}000\,x^2 + 30x - 32 = 0$

$\Rightarrow 5000x^2 + 15x - 16 = 0$

$\therefore \quad x = -\frac{15 \pm \sqrt{(15)^2 - 4 \times (5000)(-16)}}{2 \times 5000}$

= 0.055m = 5.5cm.

40. (d) $F = -\frac{dU}{dy} = b - 2ay$

41. (d) $dU_{(x)} = -Fdx$

$\therefore \quad U_x = -\int_0^x Fdx = \frac{kx^2}{2} - \frac{ax^4}{4}$

$U = 0$ at $x = 0$ and at $x = \sqrt{\frac{2k}{a}}$; $\Rightarrow$ we have potential energy zero twice (out of which one is at origin). Also, when we put $x = 0$ in the given function, we get $F = 0$. But $F = -\frac{dU}{dx}$

$\Rightarrow \quad$ At $x = 0$; $\frac{dU}{dx} = 0$ i.e. the slope of the graph should be zero. These characteristics are represented by (d).

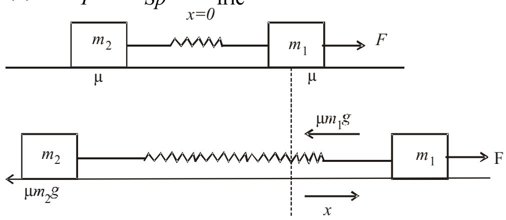
42. (c) For the smaller block to move $kx_0 = \mu mg$ and from work energy theorem

$-\mu Mgx_0 - \frac{1}{2}k\,x_0^2 = -\frac{1}{2}M\,v_0^2$

$+\mu Mg\left(\frac{\mu mg}{k}\right) + \frac{1}{2}k\left(\frac{\mu mg}{k}\right)^2 = \frac{1}{2}Mv^2$

$v = \mu g\sqrt{\frac{(2M+m)m}{kM}}$

43. **(a)** $W_F + W_{Sp} + W_{\text{fric}} = \Delta k$



$$\Rightarrow Fx - \frac{1}{2}kx^2 - \mu m_1 g\, x = 0 \text{ and } kx = \mu m_2 g$$

$$\Rightarrow F - \frac{1}{2}\mu m_2 g - \mu m_1 g = 0 \Rightarrow F = \mu m_1 g + \frac{\mu m_2 g}{2}$$

44. **(b)** u = 0; v = u + aT; v = aT
Instantaneous power = F × v = m. a.

$$\text{at} = \text{m.a}^2\text{.t}$$

$$\therefore \text{ Instantaneous power } = \text{m}\frac{\text{v}^2}{\text{T}^2}\text{t}$$

45. **(b)** Constant power of car $P_0 = F.V = ma.v$

$$P_0 = m\frac{dv}{dt}.v$$

$P_0 dt = mvdv$ Integrating

$$P_0 t = \frac{mv^2}{2} \qquad v = \sqrt{\frac{2P_0 t}{m}}$$

$\because$ P_0, m and 2 are constant

$\therefore$ $v \propto \sqrt{t}$

46. **(b)** $P = \frac{W}{t}$. Here, P = 2kW = 2000 W.
W = Mgh = M × 10 × 10 = 100 M and t = 60 s.
This gives, M = 1200 kg
Its volume = 1200 litre as 1 litre of water contains 1 kg of its mass.

47. **(a)**

48. **(b)** We know that F × v = Power

$\therefore$ $F \times v = c$ where c = constant

$$\therefore m\frac{dv}{dt} \times v = c \qquad \left(\therefore F = ma = \frac{mdv}{dt}\right)$$

$$\therefore m\int_0^v v dv = c\int_0^t dt \quad \therefore \frac{1}{2}mv^2 = ct$$

$$\therefore v = \sqrt{\frac{2c}{m}} \times t^{1/2}$$

$$\therefore \frac{dx}{dt} = \sqrt{\frac{2c}{m}} \times t^{1/2} \quad \text{where } v = \frac{dx}{dt}$$

$$\therefore \int_0^x dx = \sqrt{\frac{2c}{m}} \times \int_0^t t^{1/2} dt$$

$$x = \sqrt{\frac{2c}{m}} \times \frac{2t^{3/2}}{3} \Rightarrow x \propto t^{3/2}$$

49. **(b)** Power exerted by a force is given by
P = F.v
When the body is just above the earth's surface, its velocity is greatest. At this instant, gravitational force is also maximum. Hence, the power exerted by the gravitational force is greatest at the instant just before the body hits the earth.

50. **(d)** The power of body is given by = $\vec{F} . \vec{v}$ as the body is moving in circular path, centripetal force and velocity are at 90°, or power = 0.

51. **(b)** A → (1); B → (1); C → (3); D → (3)

52. **(c)** Power = $\frac{\text{work done}}{\text{time}}$

Therefore power of A, $P_A = \frac{mgh}{t_A}$

and power of B, $P_B = \frac{mgh}{t_B}$

$$\therefore \frac{P_A}{P_B} = \frac{t_B}{t_A} = \frac{4}{2} = 2:1$$

53. **(c)** Volume of water to raise = 22380 l
$= 22380 \times 10^{-3} m^3$

$$P = \frac{mgh}{t} = \frac{V\rho gh}{t} \Rightarrow t = \frac{V\rho gh}{P}$$

$$t = \frac{22380 \times 10^{-3} \times 10^3 \times 10 \times 10}{10 \times 746} = 15 \text{ min}$$

54. **(d)** Power = $\frac{\text{total work done}}{\text{time}}$

$$= \frac{\frac{1}{2}Mv^2}{t} = \frac{1}{2}(mv^2)n \left(\because \frac{M}{t} = mn\right)$$

$$= kn\left[\because K.E.\ K = \frac{1}{2}mv^2\right]$$

55. **(c)** Kinetic energy of block A

$$k_1 = \frac{1}{2}mv_0^2$$

$\therefore$ From principle of linear momentum conservation

$$mv_0 = (2m+M)v_f \Rightarrow v_f = \frac{mv_0}{2m+M}$$

According to question, of $\frac{5}{6}$th the initial kinetic energy is lost in whole process.

$$\therefore \frac{k_i}{k_f} = 6 \Rightarrow \frac{\frac{1}{2}mv_0^2}{\frac{1}{2}(2m+M)\left(\frac{mv_0}{2m+M}\right)^2} = 6$$

$$\Rightarrow \frac{2m+M}{m} = 6 \therefore \frac{M}{m} = 4$$

56. **(b)** Given,
Mass of block, $m_1 = 1.9$ kg
Mass of bullet, $m_2 = 0.1$ kg
Velocity of bullet, $v_2 = 20$ m/s
Let v be the velocity of the combined system. It is an inelastic collision.
Using conservation of linear momentum

$$m_1 \times 0 + m_2 \times v_2 = (m_1 + m_2)v$$

$$\Rightarrow 0.1 \times 20 = (0.1 + 1.9) \times v \Rightarrow v = 1 \text{ m/s}$$

Using work energy theorem
Work done = Change in Kinetic energy
Let K be the Kinetic energy of combined system.

$$(m_1 + m_2)gh = K - \frac{1}{2}(m_1 + m_2)v^2$$

$$\Rightarrow 2 \times g \times 1 = K - \frac{1}{2} \times 2 \times 1^2 \Rightarrow K = 21 \text{ J}$$

57. **(b)** $\text{Power} = \frac{\text{Work done}}{\text{Time}} = \frac{\frac{1}{2}m\left(v^2 - u^2\right)}{t}$

$$P = \frac{1}{2} \times \frac{2.05 \times 10^6 \times \left[(25)^2 - (5^2)\right]}{5 \times 60}$$

$P = 2.05 \times 10^6$ W = 2.05 MW

58. **(d)** $m = 10 \times 0.8\text{kg} = 8\text{kg}$
height of iron chain = 5m

$$P = \frac{mgh}{t} = \frac{8 \times 10 \times 5}{10} W = 40W$$

59. **(a)** Area under graph increases. Hence work done upon the particle from A to B increases.

60. **(c)** Number of particles string the blades/time $\propto$ velocity of wind
K.E. of particle $\propto$ (Velocity of wind)^2
$\therefore$ Power output $\propto$ (No. of particles striking/time) $\times$ (K.E. of particle)
$\therefore$ Power output $\propto v^3$

61. **(d)** Given force $\vec{F} = 2t\hat{i} + 3t^2\hat{j}$
According to Newton's second law of motion,

$$m\frac{d\vec{v}}{dt} = 2t\hat{i} + 3t^2\hat{j} \qquad (m = 1 \text{ kg})$$

$$\Rightarrow \int_0^{\vec{v}} d\vec{v} = \int_0^t \left(2t\hat{i} + 3t^2\hat{j}\right)dt \Rightarrow \vec{v} = t^2\hat{i} + t^3\hat{j}$$

Power P = $\vec{F}\cdot\vec{v}\ (2t\hat{i} + 3t^2\hat{j}) \cdot (t^2\hat{i} + t^3\hat{j})$
$= (2t^3 + 3t^5)W$

62. **(d)** $E = Pt = 45 \times 10^3 \times 50 \times 60 = 1.35 \times 10^8$

$$V = \frac{1.35 \times 10^8}{3.6 \times 10^7} = 3.75 \text{ L}$$

Since the motor is 20% efficient, five times as much gasoline is needed.

63. **(a)** Relation between kinetic energy and linear momentum is given as

$$\text{K.E.} = K = \frac{P^2}{2m} \Rightarrow P \propto \sqrt{K}$$

$$\frac{P_2}{P_1} = \sqrt{\frac{K_2}{K_1}} \Rightarrow \frac{P_2}{P_1} = \sqrt{\frac{4K}{K}} \Rightarrow \frac{P_2}{P_1} = 2$$

$$\Rightarrow \frac{P_2 - P_1}{P_1}\% = \left(\frac{P_2}{P_1} - 1\right) \times 100 = (2-1) \times 100 = 100$$

$$\Rightarrow \frac{\Delta P}{P_1}\% = 100\%$$

64. **(b)** Speed just before collision

$$= \sqrt{2g\ell(1 - \cos\theta_0)}$$

Speed just after collision = $e\sqrt{2g\ell(1 - \cos\theta_0)}$

From conservation of energy,

$$\frac{1}{2}me^2[2g\ell(1-\cos\theta_0)] = mg\ell(1-\cos\theta)$$

$\therefore\ \theta = \cos^{-1}\{1 - e^2(1-\cos\theta_0)\}$

65. **(a)** $m_1 v = -m_1 v_1 + m_2 v_2$,

$e = \frac{2v_1}{v}$ for limiting condition; $\frac{m_1}{m_2} < \frac{e}{2+e}$

66. **(d)** Here, $N - mg = ma = \frac{mg}{2} \Rightarrow N = \frac{3mg}{2}$

N = normal reaction

Now, work done by normal reaction 'N' on block in time t,

$$W = \vec{N}\vec{S} = \left(\frac{3mg}{2}\right)\left(\frac{1}{2}g/_2 t^2\right) \text{ or, } W = \frac{3mg^2t^2}{8}$$

67. **(b)** If just after collision, relative velocity = v then

$\frac{v}{u} = \frac{1}{2}\ \therefore\ \omega_{rel} = \frac{v}{r} = \frac{u}{2r}$

$\therefore$ time between 1st and 2nd collision,

$$t = \frac{2\pi}{\omega_{rel}} = \frac{4\pi r}{u}$$

68. **(c)** Let x_A and x_B be the position of ends A and B at time t from the block, then stretched length of the spring will be

$\ell_2 = x_A - x_B$

and so the stretch

$\Delta\ell = \ell_2 - \ell_1 = (x_A - x_B) - \ell_1$ (ℓ_1 natural length of the spring)

So, $U = \frac{1}{2}k\Delta\ell^2 = \frac{1}{2}k[(x_A - x_B) - \ell_1]^2$

$$P = \frac{dU}{dt} = \frac{1}{2}k\cdot 2(x_A - x_B - \ell_1)\left(\frac{dx_A}{dt} - \frac{dx_B}{dt}\right)$$

$P = F(v_A - v_B) \qquad F = \frac{P}{v_A - v_B}$

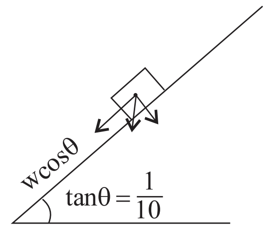
$$\Delta\ell = \frac{F}{k} = \frac{P}{(v_A - v_B)k} = \frac{20}{(4-2)\times 100}$$

$\Delta\ell = 0.1\text{ m} = 10\text{ cm}$

69. **(c)** While moving downhill power

$$P = \left(w\sin\theta + \frac{w}{20}\right)10$$

$$P = \left(\frac{w}{10} + \frac{w}{20}\right)10 = \frac{3w}{2}$$



$$\frac{P}{2} = \frac{3w}{4} = \left(\frac{w}{10} - \frac{w}{20}\right)V$$

$$\frac{3}{4} = \frac{v}{20} \Rightarrow v = 15\text{ m/s}$$

$\therefore$ Speed of car while moving downhill v = 15 m/s.

70. **(a)** As the floor exerts a force on the ball along the normal, & no force parallel to the surface, therefore the velocity component along the parallel to the floor remains constant. Hence $V\sin\theta = V^1\sin\theta^1$.

71. **(b)** According to principle of conservation of energy

Potential energy = kinetic energy

$$\Rightarrow mgh = \frac{1}{2}mv^2 \Rightarrow v = \sqrt{2gh}$$

If h_1 and h_2 are initial and final heights, then

$$\Rightarrow v_1 = \sqrt{2gh_1}, v_2 = \sqrt{2gh_2}$$

Loss in velocity,

$$\Delta v = v_1 - v_2 = \sqrt{2gh_1} - \sqrt{2gh_2}$$

$\therefore$ fractional loss in velocity

$$= \frac{\Delta v}{v_1} = \frac{\sqrt{2gh_1} - \sqrt{2gh_2}}{\sqrt{2gh_1}} = 1 - \sqrt{\frac{h_2}{h_1}}$$

$$= 1 - \sqrt{\frac{1.8}{5}} = 1 - \sqrt{0.36} = 1 - 0.6 = 0.4 = \frac{2}{5}$$

72. **(b)** $v_{s,m} = v_s - v_m \Rightarrow 0.7 = v_s - v_m$

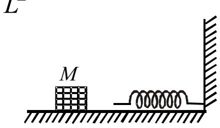
$P_i = P_f$

or $0 = 20(0.7 - v) = 50v$

or $v = 0.2$ m/s

73. **(b)** $\frac{1}{2}Mv^2 = \frac{1}{2}kL^2$

$$\Rightarrow v = \sqrt{\frac{k}{M}}.L$$



Momentum $= M\times v = M\times\sqrt{\frac{k}{M}}.L = \sqrt{kM}.L$

74. **(a)** Initial,

$$K.E. = \frac{1}{2}mv^2 = \frac{1}{2}\times\frac{20}{1000}\times 600\times 600 = 3600\text{ J}$$

Change in K.E. = P.E.

$$\frac{1}{2}m(v^2 - v'^2) = mgh$$

$$\Rightarrow 3600 - \frac{1}{2} \times \frac{20}{1000} \times v_1^2 = 4 \times 10 \times 80$$

$$\Rightarrow v_1 = 200\,m/s$$

75. **(c)** Initial kinetic energy of the system

$$K.E_i = \frac{1}{2}mu^2 + \frac{1}{2}M(0)^2 = \frac{1}{2} \times 0.5 \times 2 \times 2 + 0 = 1J$$

For collision, applying conservation of linear momentum

$m \times u = (m + M) \times v$

$$\therefore\ 0.5 \times 2 = (0.5 + 1) \times v \Rightarrow v = \frac{2}{3} m/s$$

Final kinetic energy of the system is

$$K.E_f = \frac{1}{2}(m + M)v^2 = \frac{1}{2}(0.5 + 1) \times \frac{2}{3} \times \frac{2}{3} = \frac{1}{3}J$$

$\therefore$ Energy loss during collision

$$= \left(1 - \frac{1}{3}\right)J = 0.67J$$

76. **(b)**

77. **(a)** Extra power, $P = mg \sin\theta \times v$

$$= Mg \times \frac{h}{s} \times v = \frac{Mghv}{s}.$$

78. **(d)** $P_{out} = \frac{mgh}{t} = \frac{9000 \times 10 \times 10}{5 \times 60} = 3000\ W$

$P_{in} = 10 \times 10^3$ W.

$$\therefore\ \eta = \frac{P_{out}}{P_{in}} \times 100 = \frac{3000}{10 \times 10^3} \times 100 = 30\%$$

79. **(a)** Given, h = 60m, g = 10 ms^{-2},

Rate of flow of water = 15 kg/s

$\therefore$ Power of the falling water

$= 15\ kgs^{-1} \times 10\ ms^{-2} \times 60\ m = 900$ watt.

Loss in energy due to friction

$$= 9000 \times \frac{10}{100} = 900 \text{ watt.}$$

$\therefore$ Power generated by the turbine

= (9000 – 900) watt = 8100 watt = 8.1 kW

80. **(b)** The centripetal acceleration

$$a_c = k^2 r t^2 \text{ or } \frac{v^2}{r} = k^2 r t^2 \quad \therefore \quad v = krt$$

So, tangential acceleration, $a_t = \frac{dv}{dt} = kr$

Work is done by tangential force.

Power $= F_t \cdot v \cdot \cos 0° = (ma_t)(krt) = (mkr)(krt)$

$= mk^2r^2t$

81. **(b)** $m(2v) + 2mv = 0 + 2mv' \cos 45°$ or $v' = 2\sqrt{2}v$

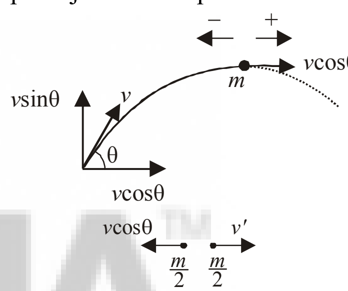
82. **(d)**

83. **(c)** Energy lost in the collision is

$$\Delta E = \frac{1}{2}mu_{rel}^2\left(1 - e^2\right)$$

$$\therefore \frac{3}{16}\left(\vec{u}_1 - \vec{u}_2\right)^2 = \frac{1}{2}mu_{rel}^2(1 - e^2) \Rightarrow e = 0.5$$

84. **(a)** As one piece retraces its path, the speed of this piece just after explosion should be $v\cos\theta$



(At highest point just after explosion)

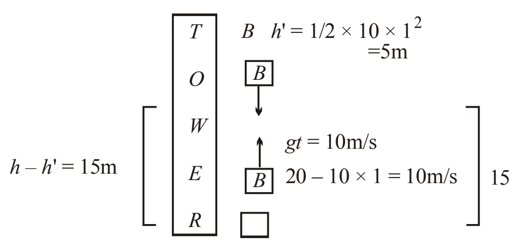
Applying conservation of linear momentum at the highest point;

$$m(v\cos\theta) = \frac{m}{2} \times v' - \frac{m}{2} \times v\cos\theta$$

$3v\cos\theta = v'$

85. **(b)** Using relative velocity, time of flight before collision will be

$$t = \frac{20}{20} = 15$$



By *COM* at the time of collision

$3 \times 10 - 1 \times 10 = 4 \times v$

$2 \times 10 = 4 \times v;\ 5 = v$

$v = 5$ m/s

For 1-D motion
$v^2 = u^2 + 2as = 5^2 + 2 \times 10 \times 15 = 25 + 300 = 325$
$K = 650$ J

86. **(a)** When the force retards the motion, the work done is negative.
Work done depends on the angle between force and displacement $W = Fs\cos\theta$

87. **(d)** When a body slides down on inclined plane, work done by friction is negative because it opposes the motion ($\theta = 180°$ between force and displacement)
If $\theta < 90°$ then W = positive because $W = F.s.\cos\theta$.

88. **(b)** (A)→(3); (B)→(1); C→(2,3); (D)→(1)

89. **(c)** In the first case the mechanical energy is completely converted into heat becuase of friction. *i.e.*, Decrease in mechanical energy = $\frac{1}{2}mv^2$.
While is second case, a part of mechanical energy is converted into heat due to fiction but another part of mechanical energy is retained in the form of potential energy of the block. *i.e.*, Decrease in mechanical energy = $\frac{1}{2}mv^2 - mgh$
Therefore statement 1 is correct.
Statement 2 is wrong. The coefficient of friction between the block and the surface does not depend on the angle of inclination.

90. **(a)** We have $K.E = \frac{1}{2}mV^2$

$$\frac{d}{dx}(K.E) = \frac{1}{2} \times m \times 2V\frac{dV}{dx}$$

Slope of (K.E – x)curve = ma ∝ a
So, (I) is correct
When ball just strike the ground, then

$$V = \sqrt{30^2 + 2 \times 10 \times 15} = \sqrt{1200}\,m/s$$

If ball reaches the same height after striking the ground then, velocity after collision = 30 m/s

$$So,\ \Delta E = \frac{1}{2}m(1200 - 900) = \frac{1}{2}m \times 300$$

$$\frac{\Delta E}{E} \times 100 = \frac{\frac{1}{2}m \times 300}{\frac{1}{2}m \times 1200} \times 100 = 25\%$$

So, (II) is incorrect.
Now, equation of motion are independent of mass. So velocity will not depend on mass. So (III) is incorrect.

91. **(a)** **92.** **(a)** **93.** **(a)** **94.** **(a)** **95.** **(b)**

96. **(2)** Work done by A = Work done by B
$F_A\, d\cos 45° = F_B\, d\cos 60°$

$$\Rightarrow F_A \times \frac{1}{\sqrt{2}} = F_B \times \frac{1}{2} \Rightarrow \frac{F_A}{F_B} = \frac{\sqrt{2}}{2} = \frac{1}{\sqrt{2}}$$

$\Rightarrow x = 2$

97. **(2)** Using energy conservation for plane AB

$\frac{1}{2}mu^2 = mgh$ (Here, u = initial velocity of block)

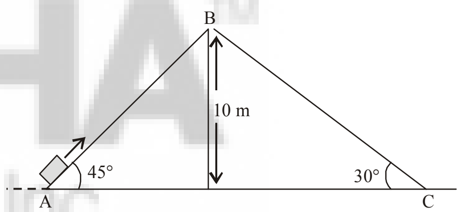
$$\Rightarrow \frac{1}{2} \times m \times u^2 = m \times 10 \times 10 \Rightarrow u = 10\sqrt{2}$$

At point B

$$\text{Acceleration, } a = -g\sin 45° = \frac{-10}{\sqrt{2}}$$

Using $v = u + at_1$

$$\Rightarrow 0 = 10\sqrt{2} - \frac{10}{\sqrt{2}}t_1 \Rightarrow t_1 = 2 \text{ sec}$$



For plane BC

Using $s = ut_2 + \frac{1}{2}at_2^2$

$$\Rightarrow \frac{10}{\sin 30°} = \frac{1}{2}(10\sin 30°)t_2^2 \quad \left(\because s = \frac{10}{\sin 30°}\right)$$

$\Rightarrow t_2 = 2\sqrt{2}$
So total time $T = t_1 + t_2$
$= 2\sqrt{2} + 2 = 2(\sqrt{2} + 1)$ sec

98. **(1)** For elastic collision $KE_i = KE_f$

$$\frac{1}{2}m \times 25 + \frac{1}{2} \times m \times 9 = \frac{1}{2}m \times 32 + \frac{1}{2}mv_B^2$$

$$34 = 32 + V_B^2 \Rightarrow V_B = \sqrt{2}$$

$$KE_B = \frac{1}{2}mv_B^2 = \frac{1}{2} \times 0.1 \times 2 = 0.1J = \frac{1}{10}J$$

$\therefore x = 1$

99. **(18)** Given, Mass of the body, $m = 2$ kg
Power delivered by engine, $P = 1$ J/s
Time, $t = 9$ seconds
Power, $P = Fv$

$$\Rightarrow P = mav \qquad [\because F = ma]$$

$$\Rightarrow m\frac{dv}{dt}v = P \qquad \left(\because a = \frac{dv}{dt}\right)$$

$$\Rightarrow v\ dv = \frac{P}{m}dt$$

Integrating both sides we get

$$\Rightarrow \int_0^v v\,dv = \frac{P}{m}\int_0^t dt$$

$$\Rightarrow \frac{v^2}{2} = \frac{Pt}{m} \Rightarrow v = \left(\frac{2Pt}{m}\right)^{1/2}$$

$$\Rightarrow \frac{dx}{dt} = \sqrt{\frac{2P}{m}}t^{1/2} \qquad \left(\because v = \frac{dx}{dt}\right)$$

$$\Rightarrow \int_0^x dx = \sqrt{\frac{2P}{m}}\int_0^t t^{1/2}\,dt$$

$$\therefore \text{ Distance, } x = \sqrt{\frac{2P}{m}}\frac{t^{3/2}}{3/2} = \sqrt{\frac{2P}{m}} \times \frac{2}{3}t^{3/2}$$

$$\Rightarrow x = \sqrt{\frac{2\times 1}{2}} \times \frac{2}{3} \times 9^{3/2} = \frac{2}{3} \times 27 = 18\,m$$

100. **(16)** Given,
Mass of engine - wagon system, m = 40,000 kg
Velocity, v = 72 × 5/18 = 20m/s

$$\text{K.E} = \frac{1}{2}\text{mv}^2 = \frac{1}{2} \times (40,000) \times (20)^2 = 8000000\,\text{J}$$

As 90% of K.E of system lost in friction, only 10% is
transfered to spring.

$$\therefore \frac{1}{2}\text{Kx}^2 = \frac{10}{100} \times 8000000$$

$$\Rightarrow \frac{1}{2} \times \text{K} \times 1 \times 1 = 800000$$

$$\Rightarrow \text{K} = 16 \times 10^5\ \text{N/m}$$